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SPATIAL DISORIENTATION RESEARCH ON THE DYNAMIC ENVIRONMENTAL SIMULATOR (DES)

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TECHNICAL REVIEW AND APPROVAL

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The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Regulation 169-3.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Peter Lurker

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Spatial Disorientation (SD) is a serious human factors problem in both the Air Force and Navy. Over 70 Class A mishaps involving nearly total loss of an aircraft or death of the pilot have been attributed to SD in the U.S. Air Force alone since 1980. Many of these SD related fatalities involve low-level turning mishaps in which the pilot is moving his head and the aircraft is at greater than 1G. The G excess illusion, an altered perception of one's attitude when G 1, is a potential player in many of these low-level turning mishaps. The purpose of this study was to assess the potential of the Dynamic Environment Simulator, a 20 ft radius, dual-gimballed, human centrifuge to generate vestibular related SD illusions, especially, the G-excess illusion. In this pilot study, the effects of head position and acceleration up to 3 G were investigated on subjects' perception of vertical. It was observed that one's error in subjective vertical increased as a function of both increasing acceleration (Gz) and increasing angle between true vertical and the resultant gravitoinertial force.

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PREFACE

The research described in this special report was made possible by the Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL) In-House Laboratory Independent Research (ILIR) Program. Fiscal year 88 funds were provided under element 61101F, work unit 723125D2. This research was completed as partial fulfillment of the requirements for the Degree of Master of Science, Aerospace Medicine, Department of Community Medicine, Wright State University, School of Medicine, for Sangkun "Sonny" Park, MD.

Dr Park helped conduct this research which resulted in a 1989 Master's Thesis entitled "Modification of Attitude Perception as a Function of Head Position and G." This research also paved the way for follow-on research sponsored by AFOSR involving a more in-depth investigation of the G-excess effect on the Dynamic Environment Simulator at Wright-Patterson Air Force Base.

Objective: The objective of this research was to assess the feasibility of using the Dynamic Environment Simulator (DES), a dual-gimballed human centrifuge, to conduct spatial disorientation (SD) research. The first objective of this SD research was to demonstrate in subjects the G-excess effect, an exaggerated sensation of body tilt that occurs when applied G-force on the vestibular system is greater than 1 G.

Approach: Nine centrifuge panel subjects participated in the study which was accomplished in the darkened cab of the DES (Figure 1). In experiment I, subjects were first trained to estimate their perception of down at 1 G while the DES cab was randomly placed at several different angles off of vertical (+/-120 degrees, +/-90 degrees, +/-60 degrees and +/-30 degrees). Subjects directed an arrow displayed on a TV monitor directly in front of them to their perception of "down" during these randomized cab positions. Subjects used a control dial to position the direction of the arrow (Figure 2). Five of the nine original subjects then participated in experiments II and III. Their results were the most consistent during 1 G trials. The approach in experiment II was to repeat the trials previously performed at 1 G in experiment I, but at 2.0, 2.5 and 3 Gz. In experiment III, subjects repeated experiment II, but performed the task with the CRT at an offset angle, to simulate a formation flying head/acceleration configuration (Figure 3).

Results: Interactions of head position (straight ahead or offset by 31 degrees yaw left and 45 degrees pitch up) and Gz as well as Gz vs the head angle were observed (Figure 4). Mean perceived attitudes with head straight ahead and head offset for 1 Gz to 3 Gz showed that when the head is offset, subjects demonstrated greater error in estimating the direction of the net gravitoinertial force, or "down" arrow (Figure 5). Furthermore, the G-excess effect appears to be present at G levels greater than 2.0 Gz.

Discussion: This research confirmed previous work by other researchers that the G-excess effect can be observed in a centrifuge-like device, where a sustained G>1 can be developed. Previous research on this illusion had been limited to 2.0 G principally because of the limitations of the device used. Of interest here was the observation that the effect is still present at 2.5 and 3.0 Gz. Future research will concentrate on head positions in addition to the two investigated here (straight ahead and offset) as well as higher G levels.

Conclusion: It was demonstrated that the DES can be used to conduct spatial disorientation research. Because of its computer controlled gimballs, the DES cab and its occupant can be placed at precise orientations and sustained accelerations. In this preliminary research, it was found that the G-excess effect can be generated in the DES. Subjects performed a visual attitude perception task with the head fixed looking straight ahead and with the head yawed left 31 degrees and pitched up 45 degrees. Subjective errors in the direction of the gravitoinertial force tended to increase as a function of increasing G, body tilt, and head position.

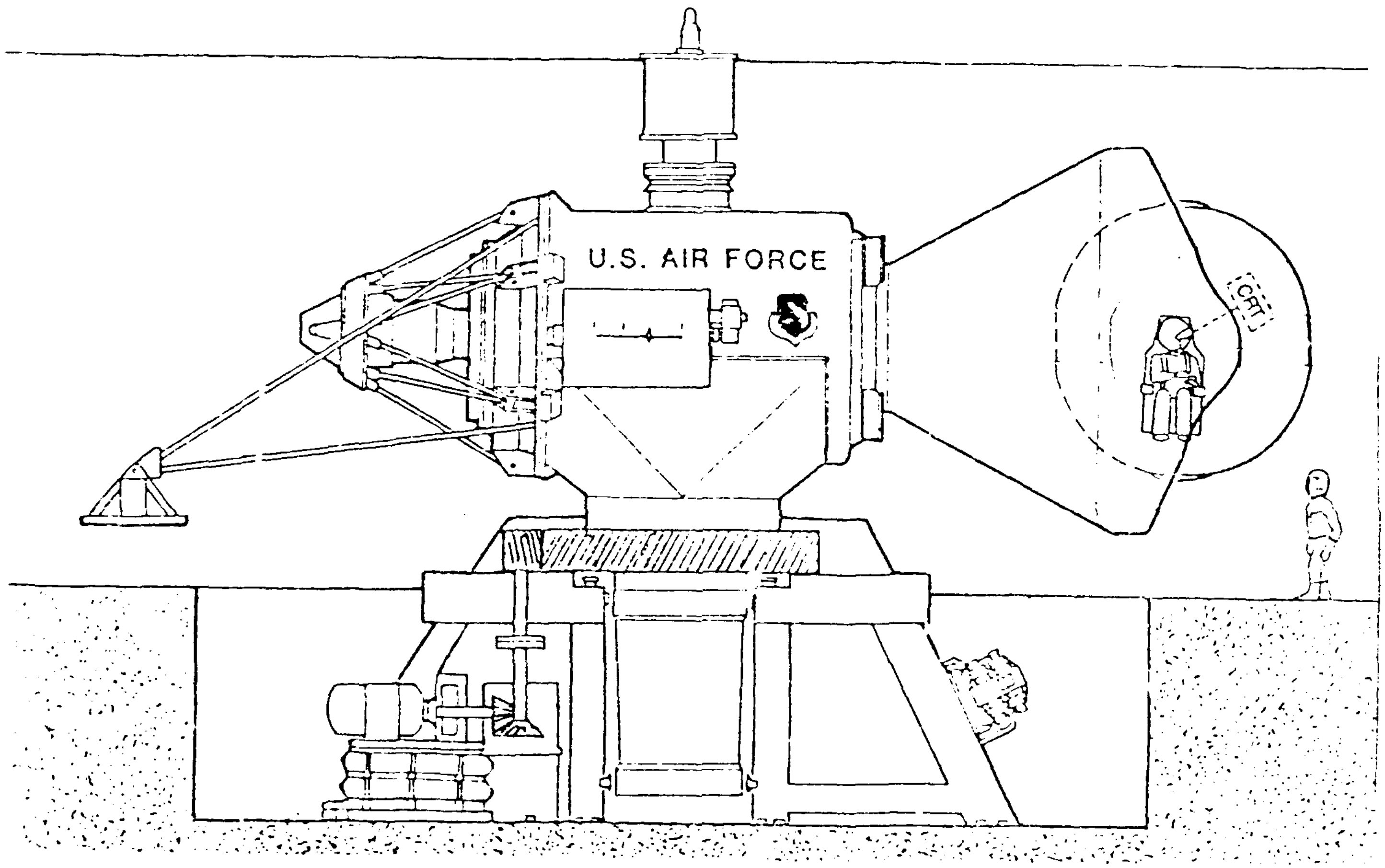


Figure 1. SPATIAL DISORIENTATION RESEARCH & DES GONDOLA AT WPAFB, DAYTON, OHIO

Figure 2. EXPERIMENTAL DESIGN IN DES GONDOLA

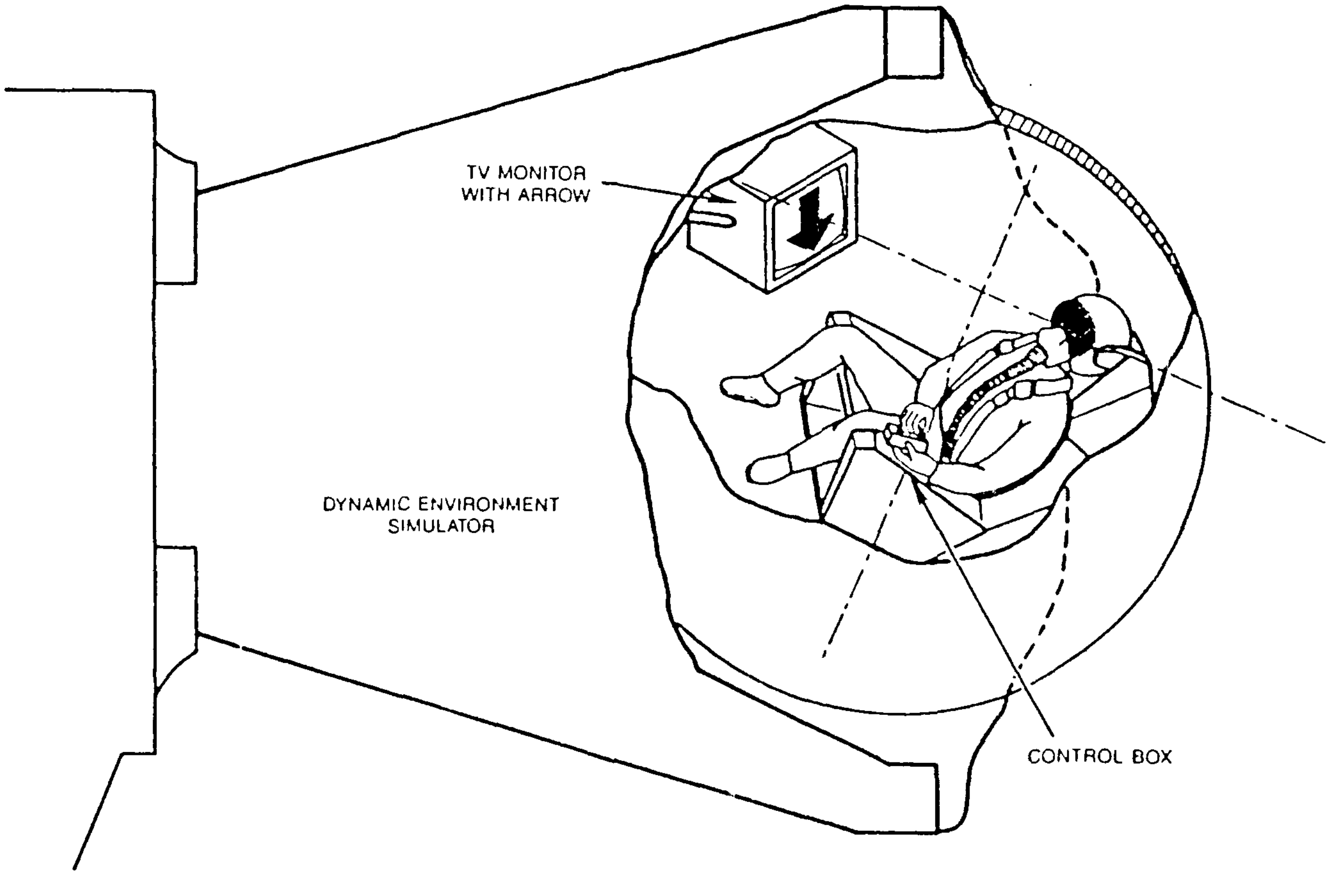
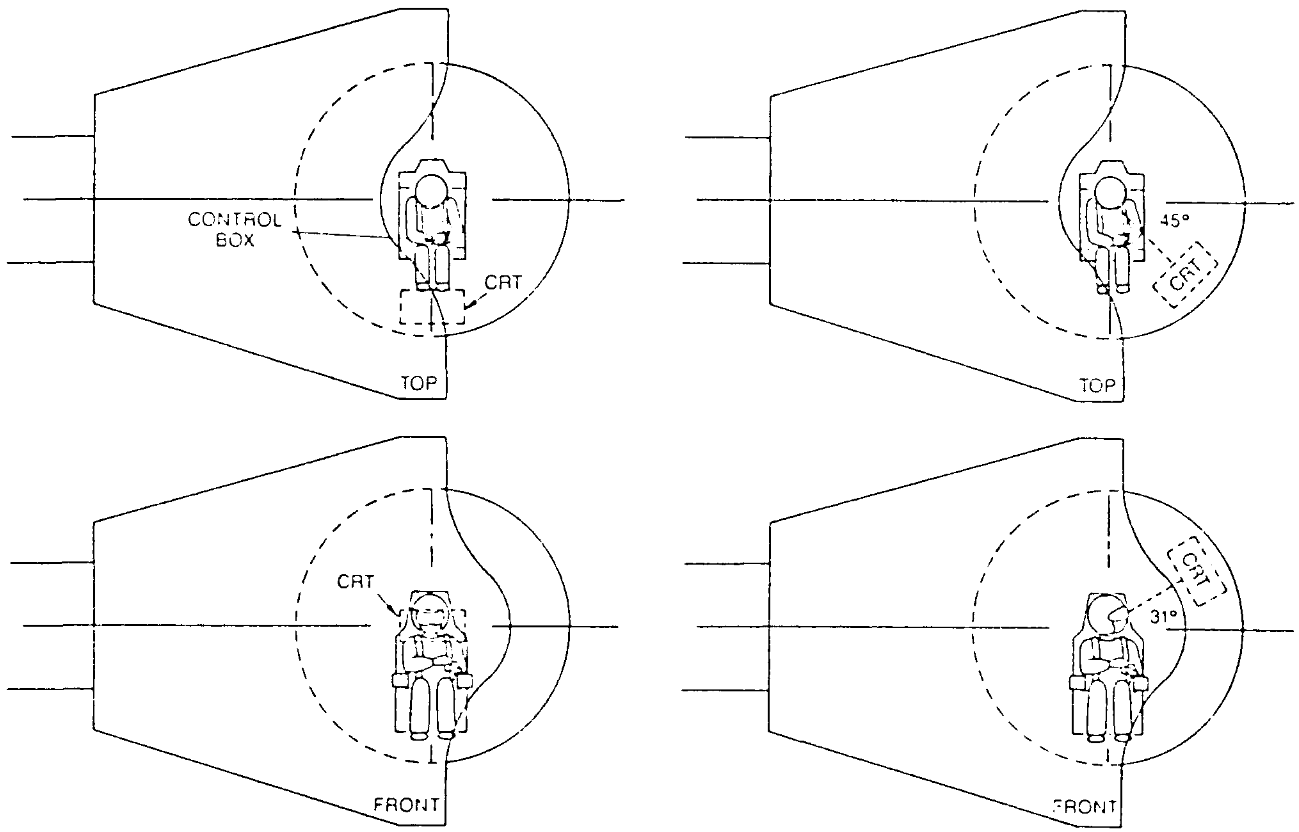


FIGURE 3. HEAD POSITIONS IN THE DYNAMIC ENVIRONMENT SIMULATOR

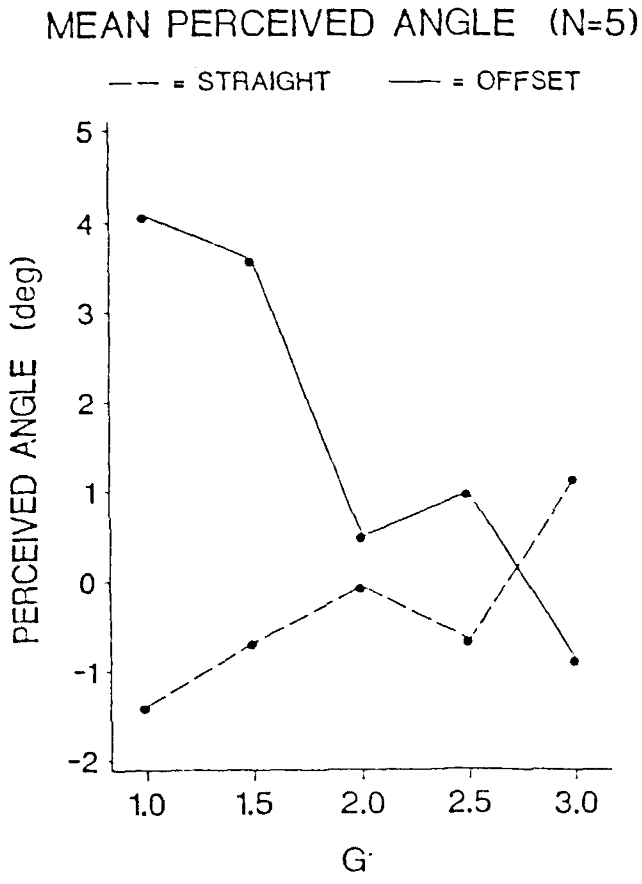


FORWARD VIEWING POSITION

EXPERIMENT II

FORMATION FLYING POSITION

EXPERIMENT III



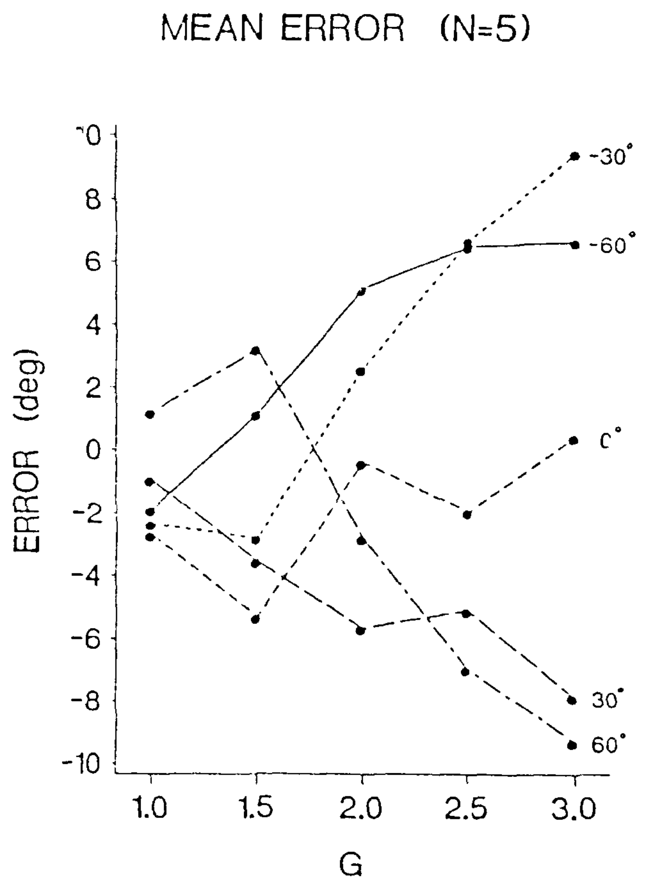


Figure 4. INTERACTIONS OF HEAD POSITION vs. Gz AND Gz vs ANGLE (Gz Value applies to angle of 0 degree)

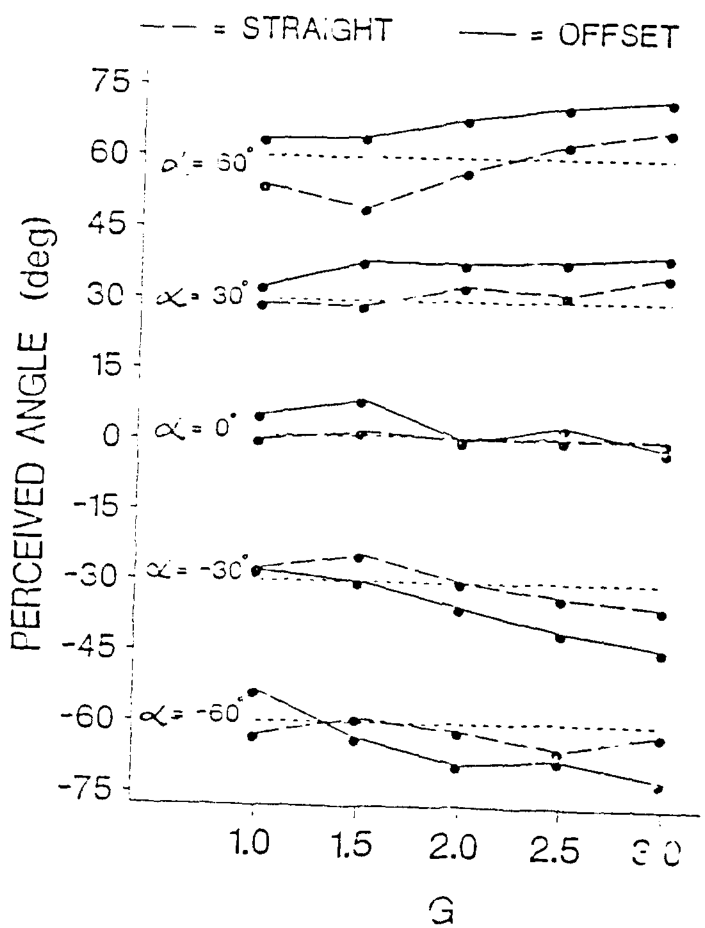


Figure 5. MEAN PERCEIVED ANGLES OF HEAD STRAIGHT AND HEAD OFFSET (Gz values apply to α=0)